JACOBI (Mary P.)

Sphygmographic experiments upon a human brain ××××

Jacobi (M.P.)

the scapula, and undergoing rapid colloid degeneration. This diagnosis was verified by Dr. W. F. Bull and Dr. G. L. Peabody, both of whom examined the tumour.

It is not my intention to write a history of the operations involving a removal of the scapula, in part or entire, but simply to put this case on record as a contribution to the annals of conservative surgery. In the *American Journal of Medical Sciences* for October, 1868, may be found a carefully prepared paper by Dr. Stephen Rogers, of New York, in which he gives the histories of fifty-six operations, involving the loss of more or less of the scapula. Up to that time, and including Dr. Rogers's case, there had been "known to the history of surgery but nine cases of exsection of the entire scapula, with preservation of the arm." The records of whatever operations of this kind may have been done since the publication of Dr. Rogers's paper, are scattered through the pages of medical journals, and have not, in so far as I know, been tabulated.

In conclusion, I would state that I last saw my patient April 21st, 1878, at which time there appeared to be no signs of a return of the disease about the shoulder. There was also an increase in the power and extent of motion.

ARTICLE X.

SPHYGMOGRAPHIC EXPERIMENTS UPON A HUMAN BRAIN, EXPOSED BY AN OPENING IN THE CRANIUM. BY MARY PUTNAM JACOBI, M.D., OF NEW YORK.

JOSIE NOLAN, aged ten, a very healthy Irish boy, had, eighteen months previous to observation, fallen and fractured his skull in the right fronto-parietal region. According to the mother's account, he remained insensible for two hours; but recovered consciousness about two hours after the fragments of broken bone had been removed by the trepan. The mother insists that from that time the wound healed rapidly, and that the child presented no morbid symptoms, not even fever. The history is evidently imperfect. At present there is an opening in the cranial bones, $2\frac{1}{2}$ inches in the long diameter, $1\frac{1}{2}$ inches transversely. The opening is situated in the right fronto-parietal regions, about 2 inches distant from the sagittal suture, towards which the long diameter is inclined at an acute angle. The opening is covered by a membrane, much thicker at the sides near the bones than in the middle. It is to be presumed that the central portion consists exclusively of dura mater, which, near the bony margin, is thickened by the addition of the remains of periosteum. The centre of this membranous covering is habitually somewhat depressed below the level of the cranial bones, but rises and falls in regular pulsations synchronous with those of the radial artery. Ordinarily, the effect of respiration is only distinctly seen in the sphygmographic trace; but, on forced inspiration, the membranes are clearly seen to descend still further below the level of the bones, and on forced expiration to bulge above it.

Pressure upon the brain through these membranes causes no appreciable effect even on the pulse, and the boy, who has all the activity of his age, has, so far, never experienced the least inconvenience from this partial exposure of the brain. Under no circumstances, of digestion, exercise, or the influence of the various drugs administered during the experiment, was any change noticed in the colours of the membranes indicating increased vascularity in them. After exercise, they sometimes are bulging, but not always, and the effect of a temporary exertion rapidly disappears. When the boy is in a recumbent position, the level of the membranes is always higher than during the vertical position, whatever the level in the latter might be, or from whatever cause it had been effected.[1]

The case offered a unique opportunity for the study of conditions affecting intra-cranial pressure. For this purpose, Mahomed's sphygmograph was adjusted to the head of the boy, in such a manner that the lever pad rested on the thin central portions of the membranes, the rest upon the bones, and steadied by an assistant. The adjustment was always made with the boy in a recumbent position, the head but slightly elevated upon a pillow.

Before interpreting the traces, it is necessary to notice in what respects these must be expected to differ from those obtained from the expansion of an artery. It is obvious that the pulsating encephalon in our case differs from the pulsating artery: 1st, by its greater proximity to the heart; 2d, by its vertical position over the heart; 3d, by the immensely greater surface receiving the shock of the cardiac systole, and through which must be disseminated the tidal wave of blood; 4th, by the greater volume of blood thrown against this surface; 5th, by the greater freedom allowed to the excursion of the part of the brain exposed; 6th, by the greater slowness with which its mass could collapse upon the blood wave. The trace from the artery corresponds to the movement of the entire mass of fluid contained in it. But while the pulsations of the encephalon are due exclusively to the influx of arterial blood, this fluid is only one of three which are moving simultaneously in the pulsating mass, the others being the venous blood and the cephalo-rachidian fluid. 7th, the final difference to be noticed in the much greater influence of respiration upon the amount of blood contained at a given moment in the brain, as compared with that contained at the same moment in the radial artery.

These various circumstances will each have a specific effect upon the sphygmographic trace. Thus, the first five peculiarities enumerated will combine to give a much greater amplitude to the curve, or an immense increase in the height of the ascension line.

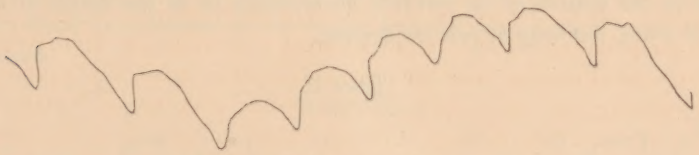
Owing to the fourth circumstance, the height of the tidal wave above the base of the percussion stroke will be greater; for, according to Ma-

[1] Since writing this paper I have seen an article in the *Centralblatt* for 1877, describing analogous experiments upon a woman's brain exposed by carcinoma. The experiments did not test the influence of drugs; but the conclusions so far as regards the normal movements of the brain agree with mine. See *Centralblatt*, Mai 12, 1877. Giacomini u. Masso, Beweg. des Gehirns.

homed, "this height indicates the amount of blood forced into the arterial system at each ventricular systole."[1] From the sixth peculiarity, the tidal wave should be more sustained. On account of the third character, there should be few oscillations from secondary waves; thus, dicrotic and elasticity oscillations should be little marked. On the other hand, the multiplication of resistances offered in the brain by fulness of its veins, or tonic contraction of its arteries, should render obliquity of the percussion stroke, and even anacrotismus of the ascending line more frequent. Finally, from (seventh) the greater influence upon intra-cranial circulation exercised by the aspirating force of inspiration, a much greater depression should occur at the moment of inspiration in the *ligne d'ensemble.*

The foregoing characters are all exhibited by the traces. The encephalic expansions, as uninfluenced by medicines, are shown in Trace No. I.; also, in Trace No. VI. before the administration of atropia, and No. X. before coffee, and under the double influence of exercise and the digestion of a full meal.

Trace I.



Under pressure 5:

Description.—Trace No. I. exhibits a peculiarity not observable in Traces VI. and X.; it possesses an anacrotic elevation, or an elevation on the ascending line.[2]

This is described by Mendel[3] as the character of the "pulsus tardus." In his schema, Landois succeeded in producing "anacrotismus" under one of three conditions, namely, when the exit opening of the schematic artery is narrowed; when the elasticity of its walls is diminished; and when, from increased volume of its contents, the internal tension is increased. Each of these conditions renders the distension of the tube by the systolic wave more difficult, hence prolongs the period of distension. Eulenberg shows that an anacrotic elevation may be obtained by compression of the artery beyond the point at which the sphygmograph is applied.

The other characters of this trace are, the well-developed tidal wave, or curve intervening between the percussion stroke and the aortic notch, and which, according to Mahomed, indicates the mass which has been thrown into the arteries by the cardiac systole; 2d, the deep inspiratory depres-

[1] Med. Times and Gaz., vol. i. 1872, p. 129.

[2] Elevation first studied experimentally by Landois. Die Lehre vom arterien Puls, Berlin, 1872.

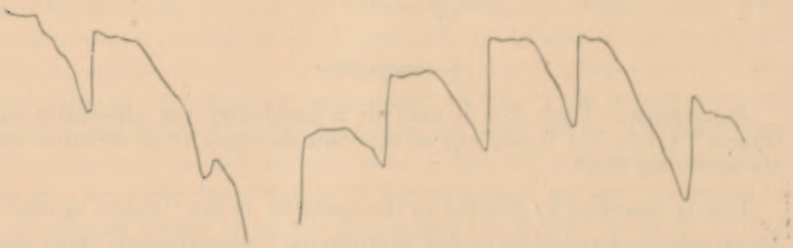
[3] Arch. Virch., Bd. 66, p. 260. See also Eulenberg, Arch. Virch., Bd. 45, 1869.

sion; 3d, the dicrotic elevation is slight, but more marked than in other traces.

Interpretation.—These characters, together with the short but vertical percussion stroke, indicate increased cerebral resistance with a large volume of blood in active circulation. The larger the mass to be aspired into the thorax at inspiration, the more marked must be the depression in the line of cerebral expansions, or the *ligne d'ensemble* of the trace.[1] The slightly increased dicrotism in the trace is to be referred to the state of the membranes, which were depressed, and flaccid, not tense or bulging. It was clear, therefore, that, notwithstanding the considerable tidal wave, the brain was not at the time distended. In another trace, taken when the membranes were tense and bulging, dicrotism had entirely disappeared. It is to be inferred that the tonic resistance of the bloodvessels was at this time great. Such a condition would at once explain the great resistance offered to the cardiac systole, causing anacrotismus, and the diminished tension of the membranes, permitting slight dicrotismus. The radial pulse showed high tension, and complete absence of dicrotism.

Hence, important corollary, we must conclude *that intracranial pressure* (such as would distend the membranes) *is not necessarily in proportion to the tension of the cerebral bloodvessels, or to the height of their tidal wave, but may be just the reverse.*

Trace II.



Pressure 5, two hours after 5 grs. of sulphate of quinia. Pulse 90.

Description.—Trace No. II. may be described as follows: Percussion stroke perfectly vertical and very high (by exact measurement one-third higher than in Trace No. X., the next highest observed). The angle between the percussion stroke and the line of descent of the preceding curve is very acute. Entire absence of anacrotismus. The systolic apex forms an acute angle, and is followed, not by a rounded curve, but by a horizontal, even slightly concave line. The tidal wave is very small. The line of descent is abrupt, and the dicrotic elevation very near to its terminus. Finally, the inspiratory depression in the *ligne d'ensemble* is enormous.

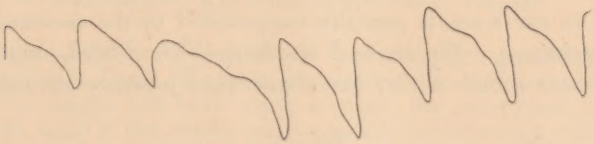
[1] The percussion stroke is shorter during inspiration than during expiration. Since at this moment the cerebral resistance is diminished, this shortening must be due, not to increased resistance, but to diminished force of the heart. This diminution is caused by the "negative pressure" exercised on the heart during the expansion of the thorax, and thus is secured a real intermittence in the blood-pressure to which the brain is subjected.

The membranes bulged more at each cardiac systole than before the administration of the quinia, but were not tense.

Interpretation.—The height and vertical direction of the percussion stroke are not exclusively due to increased energy of the cardiac systole, since when this is obtained by brandy the percussion stroke is much lower (see Trace No. IV.). Hence, in addition to the effect on the heart, there must be diminution of the intra-cranial resistance. The acute angle of the systolic apex implies an instantaneous momentary collapse of the cerebral bloodvessels after their distension by the percussion stroke. From the smallness of the tidal wave we must conclude that little blood is retained in the arteries at any given time. But the prolonged horizontal line between the systolic apex and the summit of the tidal wave, implies a sustained tension of the arterial walls. The line resembles that observed in traces from atheromatous arteries. But the abrupt line of descent indicates powerful elastic contraction of the arteries, contrary to what is seen in atheroma.

Conclusion.—By a tonic dose of quinia, the energy of the cardiac systole is increased; the tonus and elasticity of the walls of cerebral bloodvessels are also increased, so that the blood is forced rapidly on through the capillaries, thus diminishing the resistance to the cardiac systole. More blood is admitted to the brain, but the intra-cranial pressure is lessened.

Trace III.



Two hours after 20 grs. of quinia. Pressure 5. Pulse 96. Temperature fallen one degree. Membranes depressed.

Description of Trace III.—Percussion stroke vertical, but shorter than in Trace II. Systolic apex angle acute, and followed by descending instead of horizontal line. Tidal wave unequally developed, in some curves almost absent, in all very small, and far below the level of systolic apex.

Interpretation.—Diminished intra-cranial resistance to percussion stroke; nevertheless, small amount of blood thrown into brain, rapid and complete collapse of cerebral arteries.

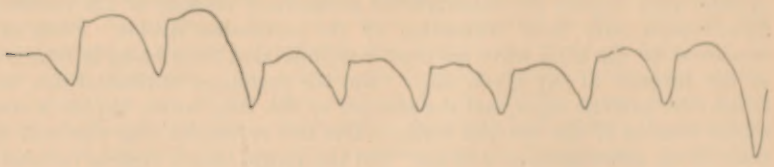
Conclusion.—Diminished energy of cardiac contractions, unfilled cerebral arteries, great diminution in intra-cranial pressure.

It is important to notice that the radial pulse taken at this time exhibited a relatively much larger tidal wave and higher tension than was shown by these cerebral traces. We should infer therefore *that the diminution of intra-cranial pressure was out of proportion to the general diminution of pressure in the arterial system connected with sedation of the heart.*

Description of Trace IV.—Percussion stroke not quite vertical, much shorter than after quinia; systolic apex forming a right, instead of an

acute angle; tidal wave greatly developed; line of descent oblique and gradual; angle between it and the following percussion stroke rather wide; dicrotism scarcely perceptible; inspiratory depressions not very marked, and much prolonged, comprising four curves, while the period of expiration comprises three.

Trace IV.



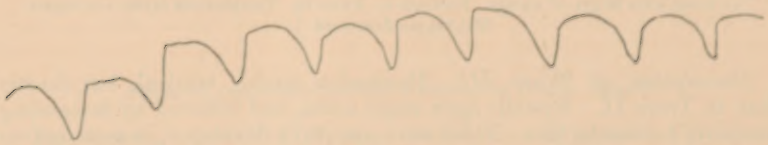
Pressure 5. After 3 drachms of brandy. Pulse 104. Membranes tense, bulging.

The membranes were tense, bulging, and affected by a peculiar heaving pulsation, not seen in any other case; the pulse was 104.

Interpretation.—Increased mass of blood in brain; increased resistance to percussion stroke dependent on this, and less than that which would be associated with contracted arteries;[1] (see Trace I.) slow collapse of arterial walls, notwithstanding rapid circulation; increased duration of inspiration; slow aspiration of blood from brain.

Conclusion is mainly expressed in the interpretation. The increased force of the heart is indicated by the radial pulse; its effect on the brain as shown in the trace, is partially compensated by the *increased intra-cranial resistance. The cerebral bloodvessels are dilated, implying diminished tonus of their walls; the intra-cranial pressure increased.*

Trace V.



After 5 gtts. tincture belladonna ter in die for four days, and 5 gtts. every three hours on fifth day. Pulse 108. Pupils moderately dilated, membranes bulging, not tense in recumbent position.

Description of Trace V.—General resemblance to Trace IV. under brandy. Percussion stroke one-fifth higher than in Trace IV.; systolic apex a right or slightly obtuse angle; tidal wave developed about as much as with the brandy; line of descent gradual, without dicrotism; absence of inspiratory depression; rise of entire *ligne d'ensemble*, as if from prolonged expiratory effort. All the characteristics of the trace were developed under a pressure of four ounces, as was not the case with brandy; but the percussion stroke was then higher than is represented in Trace V. The membranes did not bulge at all when the boy was vertical.

[1] Hence the percussion stroke, though short, is not anacrotic.

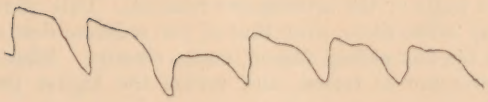
Interpretation and Conclusions.—Mass of blood in the brain increased about the same as after brandy; but intra-cranial pressure less (as shown by condition of membranes, and response to lower pressure of sphygmograph). *Expiration prolonged.*

Remarks.—From the traces alone it is rather difficult to understand why the tension of the membranes should have been so great with the brandy, and so slight with the belladonna; the rapidity of the circulation was almost the same in the two cases (pulse 104 and 108). The difference probably depends on accelerated capillary circulation in the case of belladonna, and retard of the same after brandy.

Trace VI.

Before atropia, membranes depressed.

Trace VII.



30 minutes after, $\frac{1}{64}$ gr. atropia, subcutaneously. Pulse 120.

Description.—Trace VII. Half an hour after $\frac{1}{64}$th gr. atropia shows, as compared with Trace VI., taken just before; that the percussion stroke is double the height, and more nearly vertical; the anacrotism has disappeared; the angle of the systolic apex rounded, but followed by descending instead of ascending line; tidal wave much diminished; dicrotic elevation increased, and nearer by one-fifth to the percussion stroke—that is, the duration of the ventricular systole is one-fifth less. Inspiratory depression remains the same, slightly marked, and comprising a single curve. The membranes were raised, but neither tense nor bulging. The radial pulse had become dicrotic.

Interpretation.—Relaxation of cerebral bloodvessels; consequent diminished intra-cranial resistance to percussion stroke; more rapid collapse of arterial walls; diminution in mass of blood retained in brain.

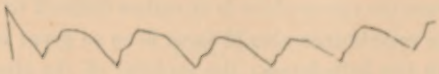
Conclusion.—Diminution of intra-cranial pressure, but increased amount of blood passing through brain in given time; on account of accelerated cardiac action and diminished resistance to it.

Description.—The peculiar effect produced by the drug is not perceptible in any individual trace alone, but in a comparison between the traces taken under moderate pressure (four and five ounces, Trace IX.), or under higher pressure (six ounces, Trace VIII.). In this the ascending stroke is anacrotic, in the others not. The tidal wave is also much less developed.

Interpretation.—The increase in pressure of the sphygmograph lever is transmitted to the cerebral arteries, so as to offer decidedly increased

resistance to the ventricular systole, and instead of developing the percussion stroke, breaks it. That such slight increase of pressure is able to cause anacrotismus, shows that *the force of this systole, i. e., of the heart's*

Trace VIII.



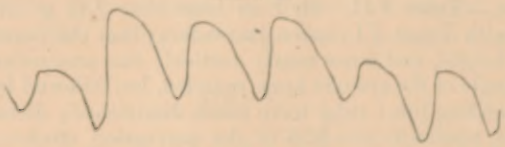
Pressure 6.

Trace IX.

2¼ hours after ½ gr. tartar emetic. No vomiting. Membranes apparently tense, bulging. Pulse 112. Pressure 5.

action, has been weakened relatively; *that the intra-cranial pressure is not only diminished*, but is easily overcome by external pressure; in other words, that the walls of the arteries are relaxed. This peculiarity is not observed in any other trace, even that of the sedative dose of quinia, but is confined to the nauseating dose of tartar emetic. After vomiting, the intra-cranial pressure is raised, and resists the higher pressure of the sphygmograph.

Trace X.



Pressure 5. Before coffee, pulse 112. Membranes tense, bulging.

Trace XI.

Pressure, 6. Half an hour after 4 oz. strong infusion coffee. Membranes much depressed. Pulse 112.

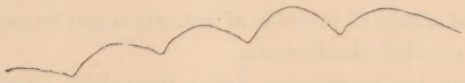
Description (Trace XI.).—Absence of inspiratory depression, which has been marked in Trace X. Percussion stroke shortened to one-fifth the height, oblique, instead of vertical; higher under pressure 6 than 5. Diminution of tidal wave. The membranes were depressed, which had been bulging. The radial pulse remains the same in rapidity, and also in the form of the sphygmographic trace (not here given).

Interpretation.—From this last fact it is evident that the percussion stroke has not been shortened by weakening the force of the cardiac contraction. The shortening must, therefore, be due to an increased resistance in the brain. As there is not an increased mass of blood in the brain,

the resistance implies increased tonicity—increased contraction of blood-vessels. This tonicity is only overcome by greater external pressure; hence percussion stroke is more developed under pressure 6 than 5 (reverse of tartar emetic).

Conclusion.—The amount of blood circulating in the brain is smaller, but it is brought to nerve tissues under increased pressure; hence assimilation of nutritive material should be increased in rapidity, if lessened in quantity. *The intra-cranial pressure, on the whole, i. e., against the membranes, is diminished.*

Trace XII.



Pressure 4. Three hours after twenty grains of bromide of potassium.

Trace XIII.

Pressure 5. Pulse 76; membranes depressed below cranial level.

Description.—Great development of tidal wave, perceptible under all pressures. At pressure 4, percussion stroke so oblique as to merge into tidal wave. Trace resembles that from an aneurismal tumour.[1] Under pressure 5, percussion stroke sometimes vertical, sometimes oblique. Line of descent prolonged and gradual, without trace of direction.

Interpretation.—The trace must be considered in connection with the facts, that the membranes had become depressed, and the tidal wave of the radial pulse extremely small under the influence of the bromide. It is to be inferred, therefore, that the large tidal wave in the cerebral trace does not depend upon an unusual amount of blood thrown into, or contained in, the brain, but upon unusual obstacles to its passage out of the brain. This implies a *contraction of the smallest bloodvessels and capillaries, the larger remaining the same, and thus offering no other obstacle to the ventricular systole than the prolonged retention of blood in them; the latter causing increased lateral pressure, identical with that of a large tidal wave.*

Conclusion.—The intra-cranial pressure, on the whole, i. e., against the membranes, is diminished; but the brain tissue is subjected to a mechanical pressure from fulness of the vascular canals before the point where they begin to be nutritive, and because of relative exclusion of the blood from the latter.

Remarks.—The descriptions of the traces of coffee and bromide read a good deal alike, except in regard to the tidal wave; but the traces are

[1] See trace given by Mahomed, Medical Times and Gazette, 1873, p. 222.

conspicuously different. The difference probably depends on the different rate of the circulation, on the different direct action of the drugs on the nerve tissues, and on the exercise of lateral pressure in the *nutritive* bloodvessels in the case of the coffee; in the canals leading to them, in the case of the bromide. In the case of the brandy an increased tidal wave was interpreted as evidence of dilatation of cerebral bloodvessels, because of the visible increase in the tension of the cerebral membranes and the state of the radial pulse which coexisted.

The characteristic trace of the bromide was not developed until three hours after its administration. It was most characteristic at a low pressure (4). It is not believed that the whole, or even the greater part of the physiological action of bromide of potassium can be explained by this effect upon the cerebral bloodvessels.

To what extent the conclusions, drawn from these observations, are in accordance with existing theories, may be considered on another occasion. On this, we content ourselves with registering the facts.

ARTICLE XI.

A CONTRIBUTION TO THE PATHOLOGY OF ORBITAL CELLULITIS.

By CHARLES STEDMAN BULL, A.M., M.D., Surgeon to the New York Eye Infirmary and to Charity Hospital.

THOUGH cases of inflammation of the tissues of the orbit are from time to time published, and though orbital cellulitis cannot be justly considered a rare disease, yet the state of our knowledge upon its pathology and etiology is still unsatisfactory. In not a few cases the obscurity which rests upon its origin needs clearing up, and the course sometimes pursued by the inflammatory process requires explanation. Yet when we come to consider the orbit more closely, it would seem as if no mystery should be attached to the subject. The large amount of adipose and connective tissue, and the numerous vessels and nerves, would naturally form a region in which an inflammatory process would easily rise and rapidly spread. In the literature of the subject the most various causes are enumerated their number being almost legion. Among the most important are acute infectious diseases, as typhus, scarlatina, etc.; facial erysipelas, foreign bodies in the orbit, wounds of various kinds; and among these may be included operations upon the eyeball, or in its immediate vicinity. Thus severe orbital cellulitis has been known to follow an operation for squint, done in the correct manner and by a very skilled hand. Sonnenburg reports such a case, in which, however, the inflammation ended in resolution and did not go on to suppuration. Laqueur has observed cellulitis to follow enucleation of the eyeball.